Treatment of Ruptured ICA during Transsphenoidal Surgery

Two Different Endovascular Strategies in Two Cases

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Summary

Rupture of the internal carotid artery (ICA) during transsphenoidal surgery is a rare but potentially lethal complication. Direct surgical repair of the ICA may be difficult and time-consuming in an acute setting. Urgent endovascular treatments with vascular plug or stent-graft have been the feasible options to date.

We desrcibe two cases of iatrogenic rupture of ICA during transsphenoidal surgery. In the first case we occluded the ICA with a vascular plug at the site of tear where cross circulation was adequate. In the second case we had to preserve the ICA with stent-graft since there was no adequate cross circulation. These two strategies are discussed below.

Introduction

Transsphenoidal surgery seems to be a reasonably safe procedure, with a mortality rate of less than 1%. However, a significant number of complications do occur [1].Although experience and thorough knowledge of the relevant anatomy can prevent many potential complications associated with transsphenoidal surgery (TSS), the risk of arterial injury cannot be completely eliminated, especially given the large number of such procedures performed and the complexity of certain cases. The most serious complication of TSS is laceration of the internal carotid artery (ICA). The presentation of this potentially fatal complication includes severe peri- or post-operative bleeding and a false aneurysm of the ICA and carotid cavernous fistula (CCF) [2]. Immediate diagnosis and prompt treatment of these symptoms is essential to prevent a fatal complication.

Direct surgical repair of such lesions may be difficult, and definitive treatment may require parent vessel sacrifice or arterial reconstruction with bypass grafting [3]. Traditionally, emergency surgical ligation has been used to treat ICA injury. This treatment itself, however, is associated with an unacceptable incidence of major complications, such as death and stroke [2,4,5], and it is often ineffective or even harmful. Recent advances in endovascular techniques have, however, created alternatives to this traditionally high-risk technique [5]. We present here our experience with two radically different endovascular strategies in two different clinical settings.

Case One

A 48-year-old man presented with episodes of headache associated with dizziness and occasional black outs in the left eye. On MRI he was diagnosed with pituitary macroadenoma with apoplexy. The adenoma was encasing the left ICA completely. He underwent transsphenoidal surgical resection of the tumor under general anesthesia. After partial resection of the tumor, the neurosurgeon noticed oozing of blood in the vicinity of the cavernous segment of the left ICA. Soon it started bleeding profusely. Roller packing was given in the sphenoid sinus and nasal cavity. By this time there was already 4.5 liters of blood loss. This was managed by giving blood transfusions, colloids and inotropic agents. There was slow oozing in the nasal packing. Hence the patient was shifted to the angiography table and a four vessel angiogram was performed with a 6F sheath in right femoral artery. There was irregularity and narrowing seen on the anteromedial wall of the distal cavernous ICA below the ophthalmic artery origin. On right ICA angiogram with left carotid cross compression there was adequate flow across the anterior communicating artery with symmetrical phlebogram. There was already significant blood loss and oozing continued in spite of nasal packing. No attempt was made to remove the packing and recheck the site of laceration of the ICA.

Occlusion of the artery at the site of tear was advocated with the patient remaining in general anesthesia. An Envoy 6F guiding catheter (Cordis Corporation, Miami, Florida, USA) was navigated into the left ICA over a 0.35 glide wire (Terumo) and parked at the anterior genu of the cavernous ICA with great difficulty. There was minimal spasm noted in the cavernous segment which was treated with 50 micrograms of NTG intra-arterially. Amplazt, a 6mm size vascular plug (AGA Medical Corporation, Golden Valley, MN, USA) premounted on a introducer wire was navigated and deployed at the site of irregularity. After 20 minutes of wait, control angiogram showed complete occlusion of the left ICA. At this point right ICA angiogram showed adequate cross circulation across the anterior communicating artery with symmetrical phlebogram. No heparin was given during the endovascular treatment. Nasal and sphenoid packing was removed and re-exploration of the surrounding of left ICA was done. There was no oozing of blood. Hence the procedure was terminated. Nasal and sphenoid packing were redone. The patient was shifted to the neurorecovery care unit. He was electively ventilated. His vital parameters were in normal range. No antiplatelets or heparin were given post procedure in anticipation of rebleeding. After 24h nasal and sphenoid packing were removed. The patient was extubated. He remained neurologically intact. There was no further epistaxis. The patient was discharged on the fifth post operative day. At follow-up six months later he was found to be symptom-free.

Case Two

A 25-year-old boy presented with a known case of craniopharyngeoma. He had been operated six months before and had undergone radiotherapy for the same in another institute. This time his CT scan and MRI showed a sellar and suprasellar mass extending bilaterally up to the medial wall of the ICA. He underwent TSS under general anesthesia. After partial resection there was leakage of blood from the right supraclinoid ICA. Hemostasis was attempted with gel foam and roller pack. However blood continued to leak. Approximately 4.8 liters of blood loss was noted. Patient was given blood transfusions, colloid and inotropic agents to maintain his BP.

The patient was shifted to an angiography table under the same general anesthesia. Four vessel cerebral angiogram was performed with a 6F sheath in the right femoral artery. Right ICA angiogram showed extravasation of the contrast from the medial wall of the supraclinoid ICA above the origin of the ophthalmic artery. The left ICA and Left VA angiograms showed a hypoplastic A1 segment of the anterior cerebral artery and absent posterior communicating artery. These desperate situations precluded sacrificing the right ICA. Hence endovascular repair of the artery with covered stent-graft was advocated. An Envoy 6F guiding catheter (Cordis Corporation, Miami, Florida, USA) was parked in the distal cervical ICA. The tear in the ICA was crossed with a Galeo hydro 0.014 microwire (Biotronik, Berlin, Germany). Then a balloon mounted 4 x 19 mm Jostent Graftmaster stent-graft (Abbott Vascular Instruments, Germany) was navigated across the tear in the artery. Controlled angiogram was performed to confirm the position of the stent-graft across the lesion. The stent-graft was inflated with 10 atm pressure. However a slow extravasation of contrast was noted. Hence the balloon was reinflated with 11atm pressure. At this point control angiogram showed complete stoppage of the contrast extravasation with a good antegrade flow into the anterior (ACA) and middle cerebral (MCA) arteries.

The control angiogram 20 minutes later showed no extravasation with good patency of right ICA, ACA and MCA .We intentionally had not primed the patient with antiplatelet therapy as there was already significant hemor-

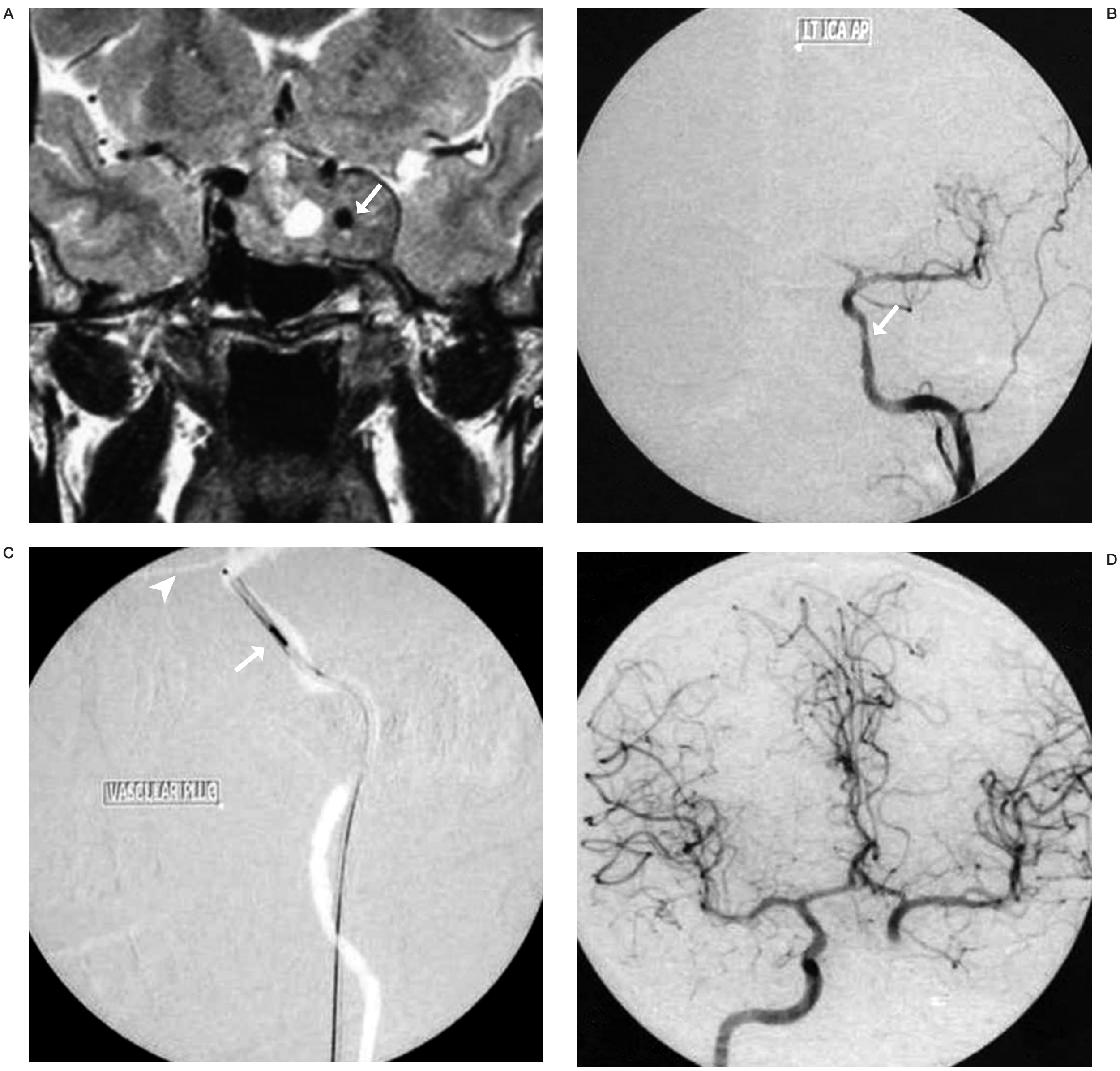

Figure 1 A) Coronal MRI of brain showed left ICA completely encased by the pituitary adenoma (arrow). B) Towne's view of left ICA angiogram showed irregular and narrowed distal cavernous segment (arrow) of left ICA (angiogram with nasal packing in place with continuous oozing of blood from nasal packs). C) Vascular plug (arrow) with distal and proximal markers deployed at the site of rupture, ophthalmic artery (arrowhead). D) Right ICA angiogram post occlusion of left ICA showed adequate cross circulation.

rhage. Verify now assay (Ultegra) (Accumetrics, San Diego, CA, USA) showed 66% inhibition of platelets function. The patient was shifted to the CT scan which then showed massive intraventricular hemorrhage. External ventricular drainage was performed. The patient was shifted to the neurointensive care unit and was electively ventilated and paralysed. Six hours later his blood pressure was continuously rising with bradycardia. His pupils became 4 mm dilated and not reacting to light stimuli. He succumbed to death after 72 hours.

Discussion

Iatrogenic injury of the ICA leading to hemorrhage is one of the most severe complications associated with TSS for pituitary lesions[2]. A survey conducted by Ciric et Al[1] suggested that the incidence of this complication is higher than was previously thought. Raymond et Al[2] reported that arterial injuries during or after TSS occurred in about 1% of cases and that they were associated with notable morbidity (24%) and mortality (14%). Injury to the vessel wall may lead to hemorrhage which can be epistaxis or intracranially into subarachnoid spaces and/or intraventricular as in our case two. Rupture of the vessel into the cavernous sinus can lead to CCF. Localized hematoma in sub-adventitial plane may become organized into a pseudoaneurysm. If blood dissects into the tunica media it will form a dissecting aneurysm. If blood dissects into the subintimal plane it will lead to narrowing of vessel lumen sometimes resulting in vessel occlusion. Factors which predispose the patient to surgical arterial injury are the size, shape and location of the pituitary adenoma. When the adenoma is large extending up to the medial wall of the ICA or encasing the ICA, arterial injury is more likely to occur[5]. Hemorrhagic complications are also more likely to occur in patients whose medical history includes either previous TSS or radiation therapy[5].

Anatomic variations in the carotid arteries and surrounding anatomy may also predispose to arterial injury during TSS. Right and left carotid arteries that are located within the sella and relatively close to each other, pose a risk for injury during TSS. In some patients, the distance between the left and right carotid arteries may be as short as 4 mm[6]. Variations in the structure of the sphenoid sinus, such as a honeycomb configuration or an opacified sphenoid sinus may also complicate TSS[5]. If any such variations in the carotid arteries or surrounding anatomy are suspected in a patient who is scheduled to undergo TSS, the patient's individual anatomy must be thoroughly assessed before surgery. Urgent intra-operative digital subtraction angiography (DSA) is to be sought if there is any uncontrollable bleeding. If there are signs and symptoms of CCF or cranial nerve palsy, MRI and DSA will confirm the diagnosis and assist in treatment planning. If the patient presents with thromboembolic complications, MRI and MR angiography should be the first choice of investigation.

Typical angiographic features of iatrogenic ICA injury after TSS may include the following: contrast media extravasation within the sphenoid sinus, carotid artery occlusion and /or stenosis, pseudo/dissecting aneurysm within the carotid artery, and CCF[2]. CCF is a rare complication associated with TSS, and it is reported infrequently in the literature[7,8]. In their study of 1800 patients undergoing TSS for pituitary adenomas, Raymond et Al[2] reported 23 arterial injuries; however, none resulted in CCF. Carotid artery injury occurs most frequently a few millimeters below the origin of the ophthalmic artery[2], and in patients with ipsilateral carotid artery stenosis, anterior or middle cerebral artery occlusion resulting from emboli may also be revealed on angiography.

Ruptured carotid artery during transsphenoidal resection is a surgical emergency and rarely life-threatening. Desperate measures need to be undertaken. DSA is to be carried out under the same general anesthesia as surgery. Rupture of the ICA usually leads to severe blood loss and cerebrovascular compromise. Anesthesiologists should be involved in resuscitation after initial hemorrhage, in securing the airway, in initiating cerebral protection strategies, and in transporting these patients[9]. In patients under general anesthesia angiographic evaluation of the intracranial collateral circulation is the sole criterion for compatibility to life. We observe for any delay between appearances of cortical veins on occluded and injected sides in the frontal view on cross compression study. Delay of more than two seconds is considered an inadequate cross circulation. Daniel Giansante Abud et Al demonstrated that BTO of the ICA based on the analysis of the symmetry of the venous phase is a safe, reliable and simple procedure to be adopted for patients undergoing permanent ICA occlusion[10]. We did not have time in both cases as there was significant blood loss. However we recommend balloon occlusion test if time permits.

In case one there was adequate cross circulation across the anterior communicating artery. Hence we decided to sacrifice the artery. Due to non availability of balloons at that point in time, we used a vascular plug to seal the tear in the artery in the distal cavernous ICA inferior to the ophthalmic artery. Occlusion of the artery at the site of the tear was important since there was a possibility of retrograde opacification of the artery through the ophthalmic artery. The Amplatzt vascular plug is designed and marketed for occlusion of the peripheral vasculature. Its use in the neurovasculature is

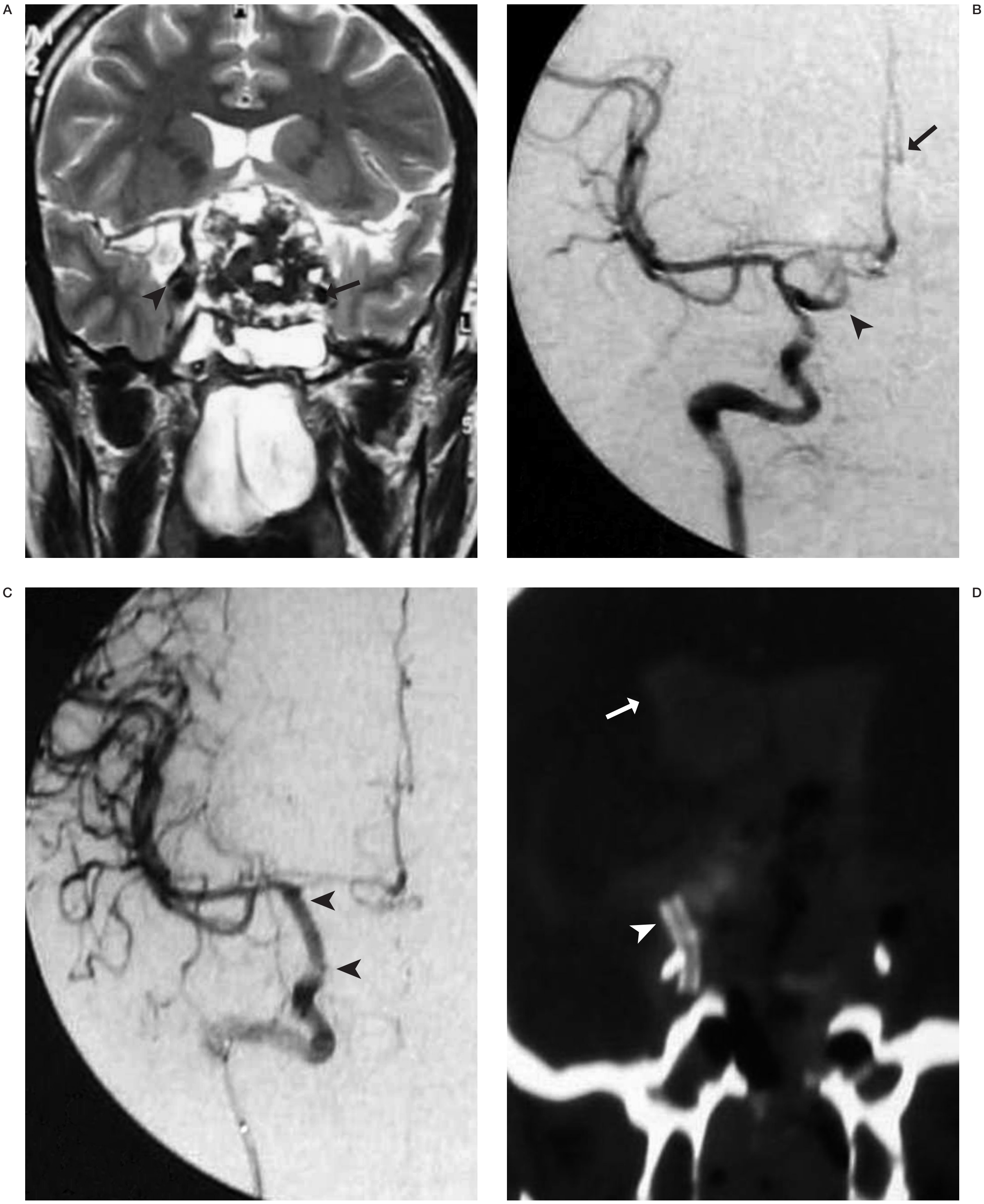

Figure 2 A) Coronal MRI of brain showed craniopharyngioma contiguous with the medial wall of the supraclinoid right ICA (arrowhead) left ICA encased (arrow). B) Right ICA angiogram showed extravasation from the medial wall supraclinoid segment (arrow head). The A1 segment is elevated superiorly and ACA is bihemispheric (arrow). C) Post-angioplasty right ICA angiogram shows smooth, parallel walled supraclinoid ICA (arrowheads) with no extravasation. D) Post-angioplasty coronal CT scan shows the stent (arrowhead) with extensive intraventricular hemorrhage (arrow).

"off-label". The plug comes in a variety of sizes, from 4 to 16 mm diameter, with 2 mm increments. The sizes that will be of most interest to neurointerventionists are 4, 6 and 8 mm plugs. The plugs of these sizes can be delivered through 5F guiding catheters (minimum ID = 0.056", maximum length = 100 cm). The cylindrical device is composed primarily of self-expanding nitinol wire mesh. There are platinum-iridium marker bands at each end. The proximal marker is welded to a stainless steel microscrew that allows detachment from the 135cm braided stainless steel delivery cable. The system is preassembled by the manufacturer; i.e., the cable and vascular plug come already screwed together and loaded into an introducer sheath. It is easy to introduce into a guiding catheter through a rotating haemostatic valve and can easily be withdrawn and repositioned through the catheter before detachment. The plug is detached by simply rotating the delivery cable in a counter-clockwise direction, which unscrews the cable from the vascular plug.

The manufacturer recommends selection of a device 30%–50% larger than the diameter of the vessel to be occluded [11]. Rossa and Buciucb [11] recommended use of the device limited to positions below the base of the skull. However Scott et Al [12] described use of this device in symptomatic aneurysms of the cavernous internal carotid artery (ICA) .To date no case has been reported in literature regarding use of this device for carotid blow out syndrome [13] in the distal segment of the cavernous ICA as in our case one. Since we had not used any anticoagulation during the procedure a single device was used to achieve complete occlusion. Two vascular plugs or proximal free coils may be required in some cases

In case two the ruptured ICA was supplying bilateral anterior cerebral artery territory. The A1 segment was hypoplastic on the opposite side. There was no posterior communicating artery on the ipsilateral side. Hence preserving the artery was an absolute necessity. Emergency treatment with endovascular stent-graft was advocated. We believed that priming the patient with antiplatelets was not required as platelet function would be low in a setting of significant hemorrhage. Antiplatelets could be added afterwards depending upon the platelet count and platelet inhibition. Point of care Platelet function tests like Verify now assay (Ultegra) (Accumetrics, San Diego, CA. USA) are recommended. Thus, so far the literature includes reports of the successful use of stent-graft to treat percutaneously inaccessible anomalies such as fistulas, aneurysms and coronary ruptures [14,15]. A few reports document the use of stent-grafts in the supraaortic arteries [16-18]. Macdonald et Al [19] recently reported the successful use of a stent-graft in the treatment of acute carotid blowout syndrome. These reports suggest that the use of stent-grafts could be the easiest and most efficient way to preserve a parent artery. They allow immediate preservation of the carotid artery and cessation of hemorrhage. The main technical limitation associated with the placement of stent-grafts within the ICA, is the limited longitudinal flexibility of the stent-graft. Adapting a semi-rigid stent-graft designed for coronary use to the curves of the ICA is somewhat difficult. We hypothesize that stent-grafts can conform to the relatively straighter segment of the ICA as in our case. There are reports of use of stent-graft in intracranial ICA aneurysms and CCF [20-22]. However, future technical developments are likely to improve stent-graft designs and offer more sophisticated delivery systems that address the current limitations of stent-grafts that are used intracranially. Ours would be the first case of the use of stent-graft in an iatrogenic laceration of terminal ICA.

Although many treatment options for acute hemorrhage associated with TSS have intermediate or long-term risks of neurological deficit or stroke, these concerns must become secondary in a potentially fatal situation in which time is of paramount importance. A recent global survey revealed that patients have a 4.4% risk of stroke within 30 days after a carotid stent placement [23]. However, we are not aware of any data that specifically document the long-term results and the risk of stroke associated with stent-graft placement within the ICA or supraaortic arteries. We hypothesize that the risk of neurological damage with the use of a stent-graft to preserve the parent vessel and prevent arterial injury is smaller than that of a parent vessel occlusion in patients who cannot tolerate the balloon occlusion test.

Polytetrafluoroethylene has been used for many years as a graft material during vascular surgery. Polytetrafluoroethylene-covered stents are effective in a variety of clinical settings, with an acceptably low incidence of complications, including acute stent thrombosis [24]. However, long-term data on restenosis rates are limited because of the small number of patients treated with coronary stent-grafts who are followed-up after their procedures.

Conclusions

We describe two radically different treatment strategies for the treatment of ruptured ICA during transsphenoidal surgery. When cross circulation was adequate sacrificing the ICA was the best option. Occluding the artery at the site of tear is of paramount importance to prevent retrograde leak. The novel vascular plug is an optimum and cheaper option to occlude the parent artery. However if cross circulation is inadequate, preserving the ICA is of absolute necessity.

In these circumstances, use of a stent-graft would be a viable option. Further studies are warranted to ascertain the safety and long-term efficacy of these strategies.

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